



NAO Prediction



ECMWF and UKMO have recently reported progress in “NAO” Prediction

- We have checked NAO prediction skill&predictability in the NMME models used at NCEP.
- Z200 (not much choice)
- February monthly means
- Initial state = Jan, 1. Week 4-8 averaged. @ Lead +1 month.
- Models CFSv2, NASA, GFDL, CMC1, CMC2, ~~CCSM3~~.
Recently added: GFDL-Flor, CCSM-4.
- Period 1982-2010 (hindcast).
- Common $1^0 \times 1^0$ ‘NMME’ grid.
- Is predictability hiding in some low dimensional sub-space?



Skill in the prediction of 'NAO'

~First Observed EOF for February Lead+1, Z200, 1982-2010



	CFSv2	CCSM4	CMC1	CMC2	NASA	GFDL	NMME	FLOR24	OBS
Skill-AC	40.7	43.3	38.0	54.4	40.2	48.1	50.4	38.9	
Predictability	50.6	60.8	44.0	62.7	60.1	58.0	52.8	35.7	
Sd-individual	3.8	3.9	3.9	4.3	4.2	4.3	4.1	3.4	5.0
SD-ens.mean	2.1	2.7	2.2	3.1	2.9	3.0	2.2	1.5	

3/6/2015: CCSM4 and FLOR24 added (NMME not redone)

All models have decent prediction skill in the NAO in week 4-8 averaged, which is a bit surprising.

Predictability is higher than the actual prediction skill in all models.
(Except GFDL-Flor)

OK, that (NMME) was 1 month means
at a lead of 1 month, but can we
predict 'modes' at a lead of 2 weeks
for wk3 and wk4 (averaged)?

- Yes, we can. And quite well Nov-April. And even (no, especially) in operations (2011-2015).
- Evidence is in the CFSv2 1999-2015 day 1-45 hindcast/forecast data+matching verification and harmonic climatologies used for SEC.
- I gave the CFSv2 data set a real workout

CFSv2 data for week 3 and week 4

or more generally day 1 - 45

- Hindcasts 1999 - early 2011, plus real time forecasts from April 2011 to the present (Feb 2015).
- Combined 1999-2015 (and ongoing)
- Initial Conditions Every 6 hours (4 cycles a day)
- Output every 6 hours as well
- Grid is global 1x1 (same as NMME grid) for height&temp (z, t) , wnd and PRMSLmsl.
- Grid is global gaussian (T126) for PRATEsfc and Tmp2m

CFSv2 data for week 3 and week 4

or more generally day 1 – 45 (contd)

Limited number of variables: To get more variables is possible).

- z1000
- z700
- **z500**
- z200
- t850
- t50
- PRATEsfc
- TMP2m
- PRMSLmsl
- wnd200
- wnd850

Location of dataset on HPSS:

/5year/NCEPDEV/emc-climate/Suranjana.Saha/cpcCFSv2Arch/45day6Hrly

CFSv2 data for week 3 and week 4

or more generally day 1 – 45 (contd)

- *Forecasts, verification and climos conveniently organized in grib files!!!*
- Jan 1999 – Mar 2011 single forecasts (every 6 hours) from CFSR IC. (and output every 6 hours)
- Apr 2011 – Jan 2015 there are 4 forecasts every 6 hours, three of them perturbed, relative to the CFSR IC.
- Verification is from CFSR (for 1X1 degree grids).
- Forecast climatology for each departure time, lead and cycle.
- Observed climatology is a single file of 366 (for each cycle)
- Including a ‘lagging’ strategy (6, 12 and 18 hours old forecasts), one can thus make an ensemble of 4 (1999-present) or 16 (2011-present).

Systematic error correction (SEC)

- Climos (both obs and forecast) were calculated (in 2011) over 1999-2010

PS: The climos were produced by the CFSv2 team, using a subroutine (4 harmonic waves plus the mean) written by Van den Dool

- If all has been done right one would expect that over 1999-2010 ('dependent period') the RMSE and the sdf become always smaller. The AC may or may not increase.
- How SEC works out on 2011-present (independent period) remains to be seen.
- If $F(\text{time, lead})$ and $A(\text{time})$ are forecast and analysis and $CF(\text{time,lead})$ and $CA(\text{time})$ are climos the SEC is executed by $F-CF$ and $A-CA$.
Raw forecasts: $F-CA$ and $A-CA$.
Lead and target time should match.

Lead	hr	rms	sdf	sdo	ac	rms	sdf	sdo	ac	rms	sdf	sdo	ac
dy		RAW					SEC			Gain	Due	to	SEC
15	360	107.9	63.3	115	38.4	107	60.4	115	39.1	-0.9	-3	0	0.7

Operational CFSv2
 February target
 500 mb 20N-pole
 2012-2015 (4 years)
 16 ens members
 Daily

Lead	hr	rms	sdf	sdo	ac	rms	sdf	sdo	ac	rms	sdf	sdo	ac	Operational CFSv2 February target 500 mb 20N-pole 2012-2015 (4 years) 16 ens members
dy		RAW					SEC			Gain	Due	to	SEC	
15	360	107.9	63.3	115	38.4	107	60.4	115	39.1	-0.9	-3	0	0.7	
16	384	109.4	60.7	115	35.4	108.1	57	115	36.5	-1.3	-3.7	0	1.1	
17	408	110.6	59.1	115	33	109.1	54.8	115	34.3	-1.5	-4.3	0	1.3	
18	432	111.8	57.7	115	30.6	110.3	52.6	115	31.7	-1.5	-5.1	0	1.1	
19	456	112.9	55.8	115	28	111.4	50	115	28.8	-1.5	-5.9	0	0.8	
20	480	114.3	54.5	115	24.9	112.8	48.1	115	25.4	-1.5	-6.4	0	0.4	
21	504	115.6	53.3	115	22	114.1	46.5	115	22.2	-1.6	-6.8	0	0.2	
22	528	116.3	52.4	115	20.3	114.7	45.2	115	20.3	-1.6	-7.2	0	0	
23	552	116.9	51.1	115	18.4	115.5	43.6	115	17.9	-1.4	-7.5	0	-0.5	
24	576	117.4	50.5	115	17.2	115.9	42.4	115	16.3	-1.5	-8.1	0	-0.9	
25	600	117.5	50.3	115	16.9	116	41.9	115	15.9	-1.5	-8.3	0	-1	
26	624	117.1	49.9	115	17.5	115.4	41.3	115	17.1	-1.7	-8.6	0	-0.4	
27	648	117.1	49.6	115	17.2	115.4	40.8	115	16.8	-1.7	-8.8	0	-0.5	
28	672	117.6	49.1	115	16.1	116	40.4	115	15.2	-1.6	-8.8	0	-0.9	

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3	72	85.2	53	91	39.6	83.4	47.3	91	41.3	-1.8	-5.7	0	1.6	
4	96	92	46.5	91	23.4	90.1	37.3	91	22.8	-1.9	-9.3	0	-0.6	
3&4	120	72.6	45.8	77.6	40.1	70.3	37.7	77.6	42.8	-2.3	-8	0	2.7	

Lead dy	hr	rms RAW	sdf	sdo	ac	rms	sdf SEC	sdo	ac	rms Gain	sdf Due	sdo to	ac SEC	Operational CFSv2 February target 500 mb 20N-pole 2012-2015 (4 years) 16 ens members
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3&4	120	72.6	45.8	77.6	40.1	70.3	37.7	77.6	42.8	-2.3	-8	0	2.7	
3	72	34.3	27.3	46.2	67.3	33.4	23.7	46.2	72.1	-0.9	-3.6	0	4.8	Mode 1 for (bi) weekly averages
4	96	43	25	46.2	39.1	41.7	18.1	46.2	42.9	-1.3	-6.9	0	3.7	
3&4	120	33.1	26.4	43.7	65.6	31.4	21	43.7	74.1	-1.6	-5.4	0	8.6	

Conclusion: (Feb 2012-2015 500mb height)

Correlation goes from 0.39 for day 15 to 0.42 for bi-weekly means,

then to 0.72 for projection onto modes.
(Also mode 2 incidentally)

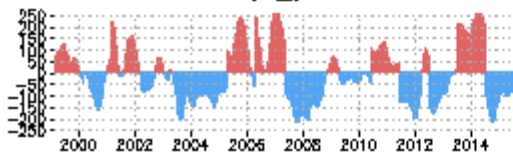
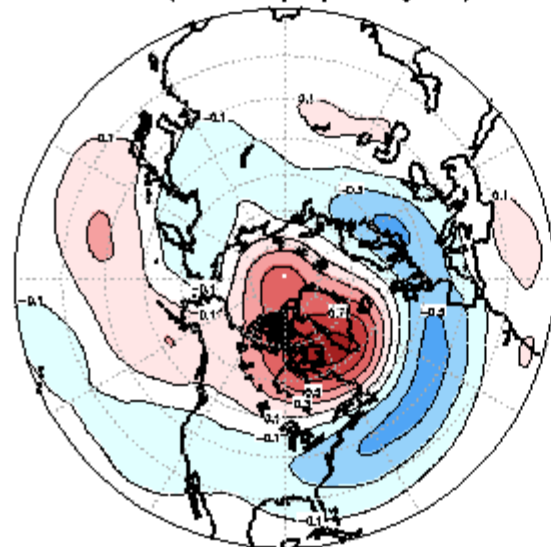
Not only in February!

In months where $AC \geq 0.2$ one or 2 modes may carry the skill
If $AC \leq 0.20$ it is hard to improve signal to noise ratio.

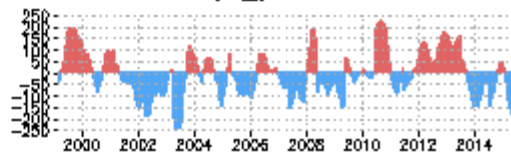
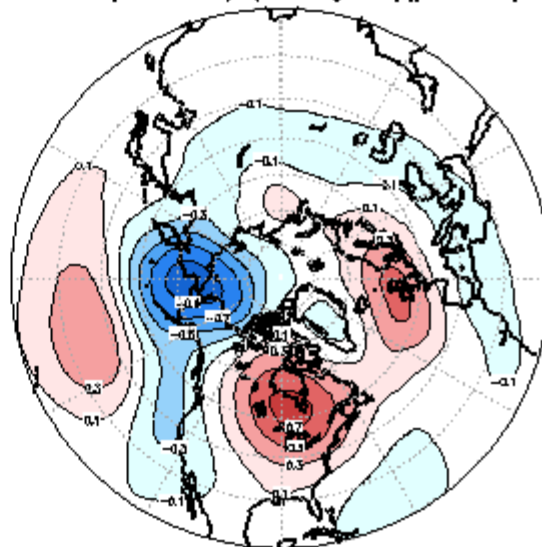
Who are these modes? No surprise....

EOF March weekly means 1999–2014 Z500

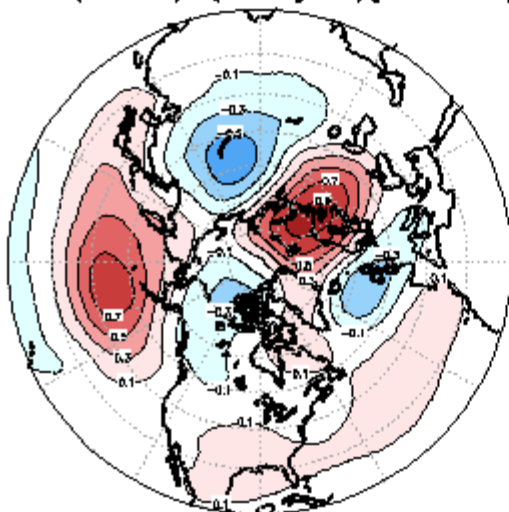
EOF1 (15.9 %EV) (seed=guess)



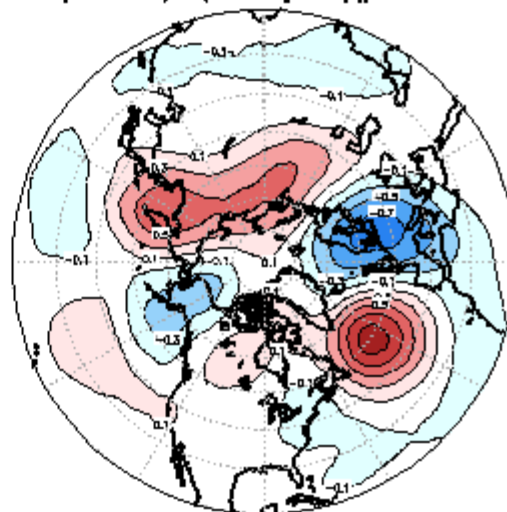
EOF2 (11.2 %EV) (seed=guess)(partial 1)



EOF3 (9.8 %EV) (seed=guess)(partial 1&2)



EOF4 (7.3 %EV) (seed=guess)(partial 1&2&3)



Weekly averages
for March only.
Based on CFSR.
400 data points
Across 16 years.

Modes among top 5 EOF that feature prediction skill ≥ 0.6 as a function of target month

Month→	1	2	3	4	5	6	7	8	9	10	11	12
Modes	2,3	1,2	1,2	1	-	-	3	-	1	-	3	1,2

1. Very little promise from May-October
2. Either 1 or 2 modes are significant from Nov-April
3. January has also modes 5 and 8 ≥ 0.6 . But not #1!!
4. Are EOFs suitable to find 'most predictable pattern'?
5. Are the July and Sept significant modes just by chance???

Questions touched upon

- How well does systematic error correction (SEC) work?? (It depends)
- Name of the game: to improve signal to noise ratio, as per : 1) (bi)weekly mean, 2) ensemble average (four LAF in hindcasts, 16 LAF including perturb operational) and 3) modal projections
- Ens averaging is by far the best operator to improve signal to noise
- Does the atmosphere initial state matter (or is the skill we see all 'forced')
- Is CFSv2 500 mb NH forecast well-behaved real time forward (in spite of a list of documented changes in 'the system'). SEC works fine on Z500.....
- In favorable months (Nov-May) there is a huge 'improvement' from 1999-2010 to 2011-2014/15. Even though SEC works on independent data.
- Are the years 2011-2015 somehow special (large, often -ve NAO?) and more predictable. Persistence may do?? Or just better IC??
- How many modes have worthwhile predictability? (1 or 2, sometimes mode 3 (only))
- Does the SEC field project onto predictable modes ?
- Don't forget: Even if mode 1 were completely predictable we predict only 15% of variance

In near future

- (Get into more detail)
- Other variables
- Complete annual cycle

To understand the codes and grib files:

- Forecasts depart from each initial time (every 6 hours) out to 45 days
- Forecast climatology is a single file of 366 for each lead and cycle.
- Observed climatology is a single file of 366 (for each cycle)
- Verification is a single file of many years.
- Understanding the above is essential for these codes to work correctly and or efficiently. Opening and closing files should be minimized.